AD-753 008

PROJECTILE LOADER FOR RESEARCH GAS GUN

William H. Holt, et al

Naval Weapons Laboratory
Dahlgren, Virginia

June 1972

AD753008

UNCLASSIFIED
Security Classification

AD-753008

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1 ORIGINATING ACTIVITY (Corporate author)
Naval Weapons Laboratory
Dahlgren, Virginia 22448

2a. REPORT SECURITY CLASSIFICATION
UNCLASSIFIED

2b. GROUP

3 REPORT TITLE
PROJECTILE LOADER FOR RESEARCH GAS GUN

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

5 AUTHOR(S) (First name, middle initial, last name)
William H. Holt
Willis Mock, Jr.

6 REPORT DATE
June 1972

7a. TOTAL NO OF PAGES
18

7b. NO OF REFS

8a. CONTRACT OR GRANT NO

b. PROJECT NO

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)
NWL TR-2763

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10 DISTRIBUTION STATEMENT
Approved for public release; distribution unlimited.

11 SUPPLEMENTARY NOTES

12 SPONSORING MILITARY ACTIVITY

13 ABSTRACT
A new type of projectile loader for a research gas gun has been designed and fabricated. The design is compared with two existing loader designs, the movable breech and the wrap-around breech. Design and fabrication details are presented. The performance of the loader is discussed.

Ia

DD FORM 1 NOV 65 1473 (PAGE 1)
0101-807-6801

UNCLASSIFIED
Security Classification

NWL Technical Report No. 2763
June 1972

PROJECTILE LOADER FOR RESEARCH GAS GUN

by

William H. Holt and Willis Mock, Jr.

Surface Warfare Department

I-b

FOREWORD

This report describes a projectile loading mechanism for a new research gas gun that is currently in operation at NWL. This loader is a new design for guns of this type.

The requirement for the gas gun is based on a NAVAIR 310B project (Task No. A310310B/291-1) to study charge carriers in ferroelectric ceramic materials under shock compression. To obtain meaningful results, the shock stress in the material must be well-defined and variable in controlled increments over the range from 2 kbar to 35 kbar. (The use of explosives does not lend itself to precision experiments in this stress range.) A suitable shock facility was not available at NWL; for this reason the design and construction of a precision gas gun was initiated.

This report has been reviewed by M. F. Rose and L. M. Williams, III.

Released by:

D. S. Malyevac

D. S. MALYEVAC
Assistant Head, Surface Warfare Department

CONTENTS

LIST OF FIGURES

I. BACKGROUND

Compressed gas guns are useful for the generation of mechanical shock waves of variable and controlled amplitude. The design of a new 40mm gas gun at NWL necessitated the selection of a projectile loading mechanism for the gun.

A gun of this type generally consists of a high-pressure gas vessel for the breech, some means of loading the projectile or piston into the gun, a mechanism for the rapid release of the driving gas from the breech, and a smooth-bore barrel. The barrel is usually evacuated to a few microns Hg pressure prior to firing; this is to minimize air cushion effects in front of the projectile.

Figure 1 is an overview of the NWL research gas gun as seen from the breech end. The position of the loader is indicated in the photograph. A schematic diagram of the gun is presented in Figure 2.

Two existing approaches to gas gun loading will be discussed and a new loader design will be presented.

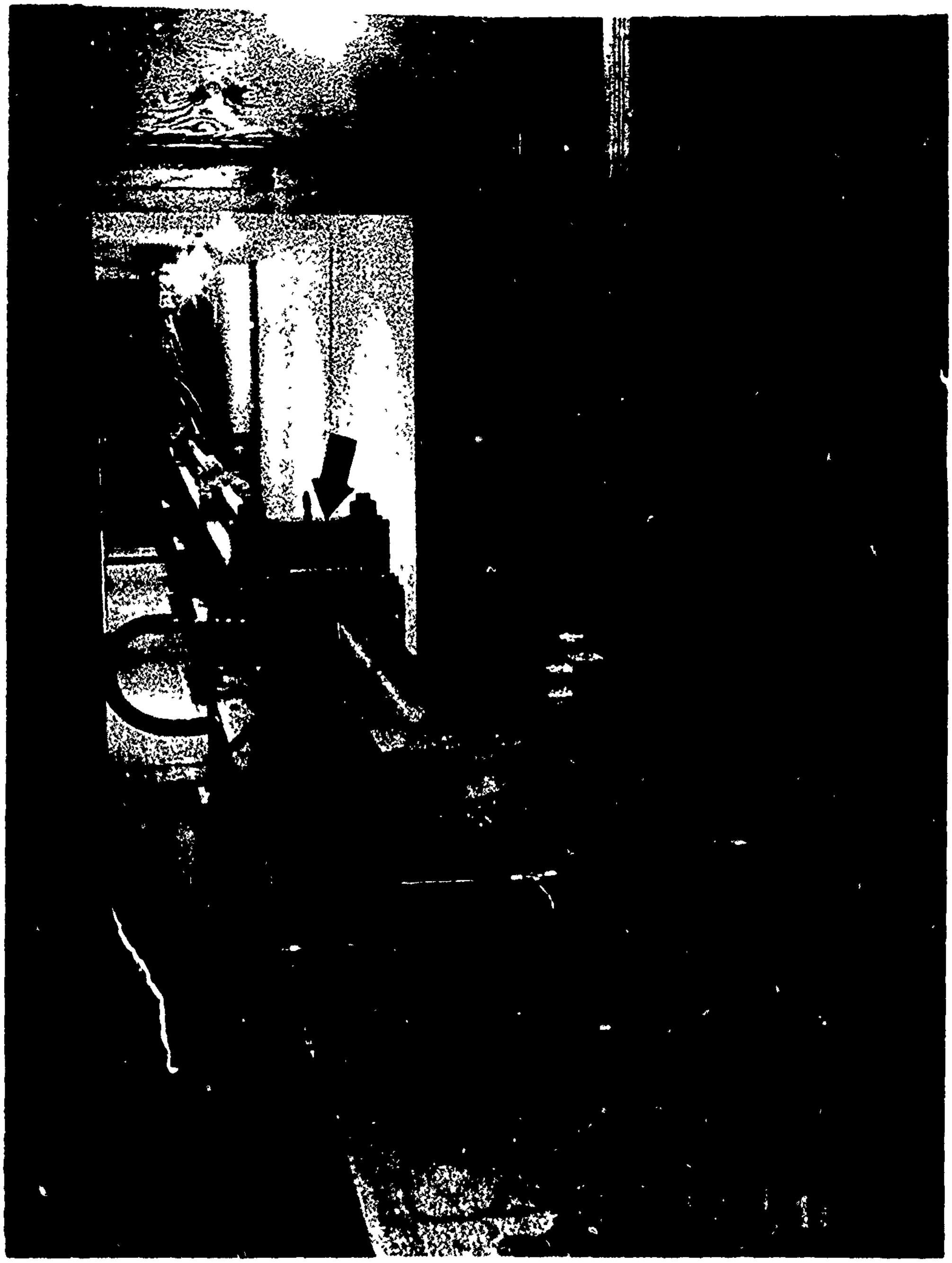

FIGURE 1

Photograph of Research Gas Gun

(This is an overview from the breech end; the top of the loader assembly is indicated by the arrow.)

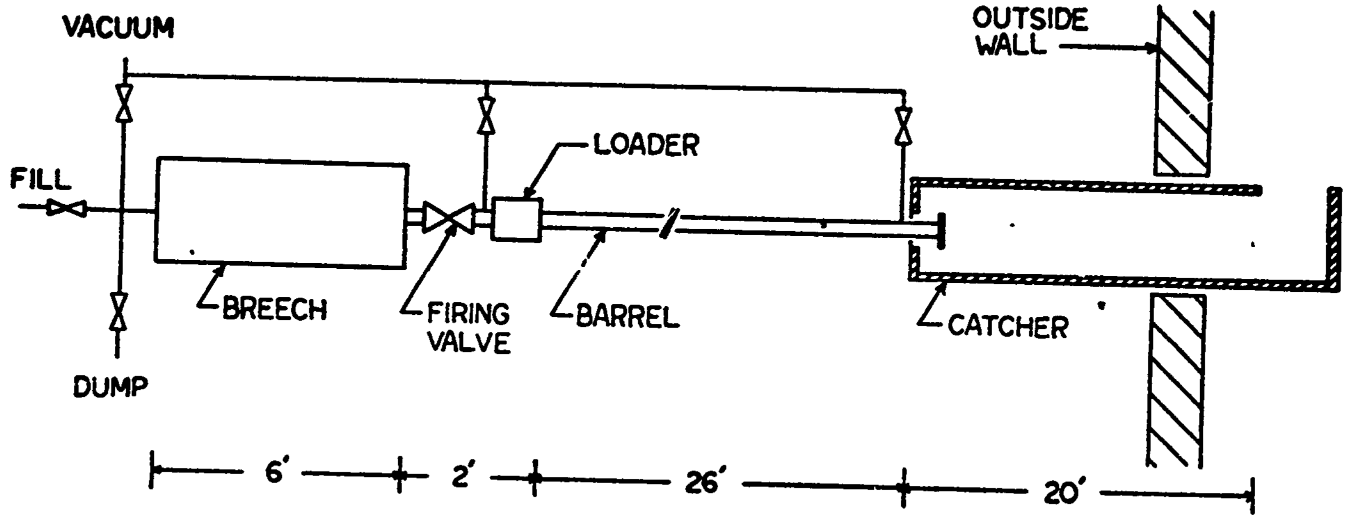

FIGURE 2

Schematic of Research Gas Gun

II. EXISTING LOADER DESIGNS

A. The Movable Breech

A common design is the movable breech. The gun is opened by disconnecting the barrel from the rest of the gun, inserting the projectile, and then reassembling the system. This type of loading has been used very successfully by Graham and co-workers (1) at Sandia Laboratories (Albuquerque). A solenoid valve or burst diaphragm may be used to release the driving gas.

This method requires a precision track-and-roller system for supporting the breech or barrel as they are moved apart. The support systems must also provide a means of realignment when the two heavy parts are brought together again, to form a seal for high pressure gas. The gun parts must then be secured to a rigid base or shock-absorbing mount to prevent uncontrolled recoil. This type of loading imposes no particular restrictions on projectile design.

B. The Wrap-Around Breech

Another approach is to use the "wrap-around" breech (see Figure 3). The pressure vessel is constructed coaxial to the barrel to obtain the best multi-port gas flow conditions; hence the name "wrap-around" was coined. The plugs at the back of the breech are removed and the projectile inserted so that it occludes gas flow from the holes connecting the barrel and the pressure vessel. The projectile must have a ring seal at each end. The body of the projectile must be strong enough to withstand the static breech pressure. The barrel is evacuated in front of and behind the projectile. An auxiliary pressure pulse is used to move the projectile forward, past the gas ports. This design is automatically fast-opening and the full breech pressure then acts on the back of the projectile. A burst diaphragm or large orifice solenoid valve is not needed. This type of loading has been used by Graham (2) and also by Duval and co-workers (3) at Washington State University.

The requirement that the projectile withstand the static breech pressure places certain restrictions on projectile design. If a hollow projectile is used to minimize projectile mass (thereby increasing the maximum attainable velocity), the material and wall thickness must be considered. A minimum wall strength for radial compression must be maintained. This determines the wall thickness and hence minimum projectile mass.

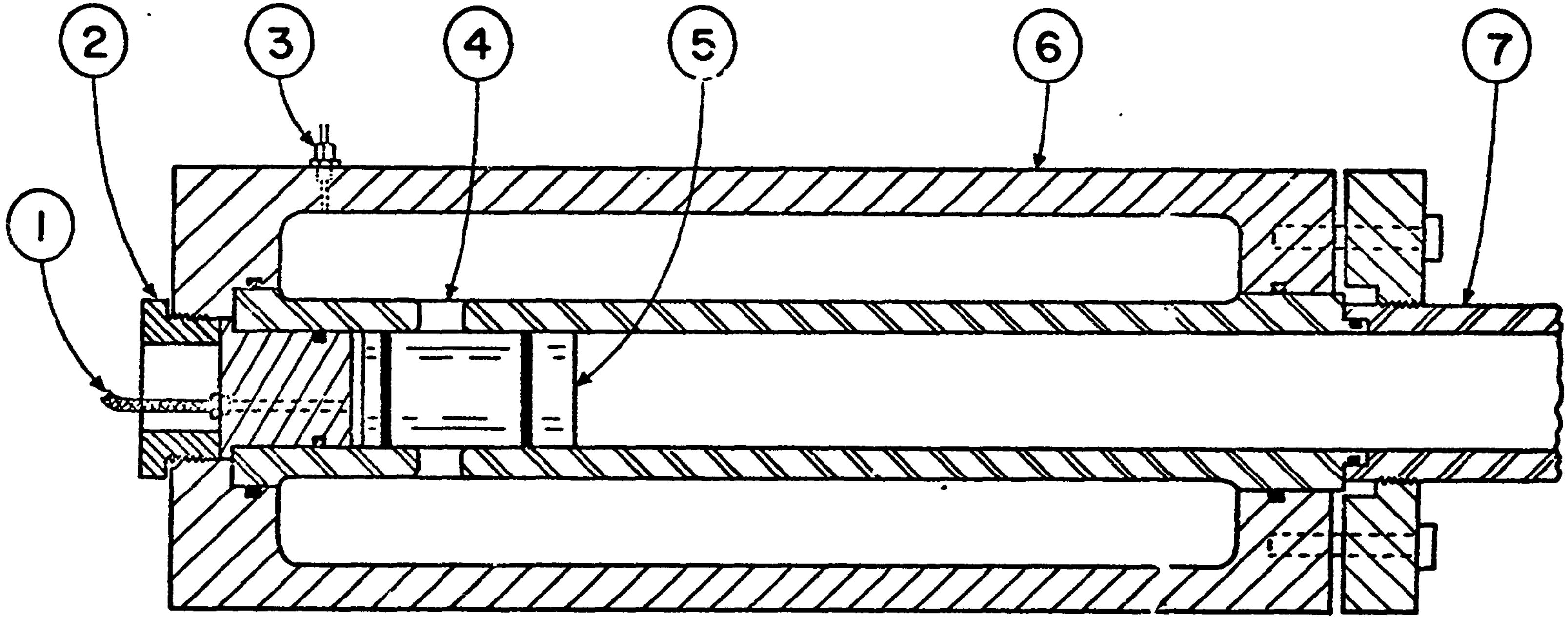

FIGURE 3

Schematic of a Wrap-Around Breech

(1) Orifice for firing pressure pulse
(2) Breech plugs
(3) Orifice for pressurizing breech
(4) Gas flow ports
(5) Projectile with O-rings
(6) Pressure vessel
(7) Barrel sections

The construction of a wrap-around breech is complicated by the need for internal seals for pressure and vacuum. Also, to obtain a useful volume (of the order of 0.6 cubic foot or more) for the high-pressure gas, one must start with a large solid cylinder and hollow out the inside.

The attractive features of each of the above approaches to loading were considered at length. The estimated cost of fabrication was also considered. We concluded that both the movable breech (based on drawings from Sandia Laboratories) and the wrap-around breech would be too costly to fabricate, relative to the funds available. We decided that for our application, the best approach would be to use a simple pressure vessel (a modified 3-inch Navy gun barrel), a fast-opening solenoid valve, and a new and simpler loader design.

III. LOADER OF NEW DESIGN

The new loader will now be described. This loader can accept solid or light-weight hollow projectiles up to 120mm long, with or without ring seals. It is not necessary to disconnect or move the breech chamber from the barrel to load. The projectile need not withstand the static breech pressure. The loader is designed for use with breech pressures up to 350 atmospheres (~5000 psi). It can be used with either a solenoid valve or a burst diaphragm as the gas-releasing mechanism.

The parts of the loader are shown in Figure 4. A section view of the loader body is used to show its internal design.

The loader body and plug have cylindrical grooves to accept the projectile and to present minimal obstruction to gas flow. (The duct for gas flow through the loader is collinear with the barrel and has the same diameter as the inside of the barrel). The vacuum and pressure seal is accomplished by an O-ring in the lip of the plug, which seals against the step-shoulder inside the loader body. A small vacuum port at the breech end of the loader permits evacuation of the region between the gas-releasing solenoid valve and the projectile. This is necessary to prevent the projectile from moving down the barrel when the barrel is evacuated.

The loader is secured to the breech-supporting I-beam by four 5/8-inch bolts. The holes are drilled and blind tapped into the bottom of the loader body. The barrel is bolted to the loader by six 1/2-inch studs, but is supported by a separate I-beam. The solenoid valve is also bolted to the loader. O-rings provide pressure and vacuum seals at the joints.

To load the gun, the projectile is placed in the groove in the loader body and pushed into the barrel to clear the loader cavity. Two pieces of 0.8mm thick rubber sheet, shaped like circular segments, are placed in the cavity (one on each side of the groove). A circular 3.2mm thick steel plate is placed in the loader and two additional segments of rubber are positioned on it. The plug is then inserted and aligned rotationally with fiducial markings on the plug and loader body. A large steel yoke is placed across the loader plug and secured by two 1½-inch bolts to the supporting I-beam.

The circular plate serves as a backstop and starting position reference for the projectile when the loader and barrel are evacuated prior to firing. The pieces of

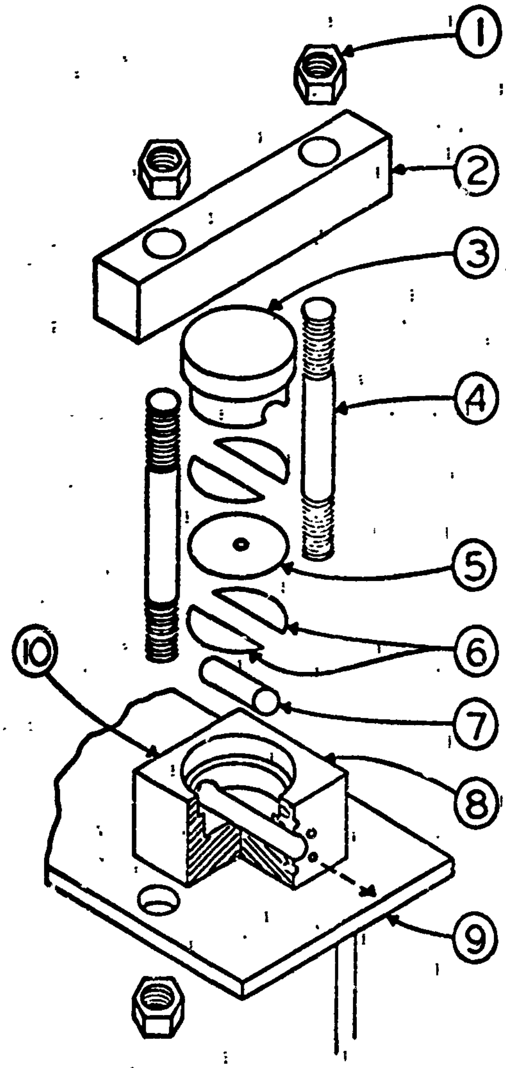

FIGURE 4

Schematic of Projectile Loader

(1) Securing nuts
(2) Yoke
(3) Plug
(4) Securing Bolts
(5) Circular plate
(6) Rubber sheet segments
(7) Projectile
(8) Loader Body
(9) Supporting I-beam
(10) Location of gas-releasing solenoid valve collinear with gas-flow orifice in loader body

The dashed arrow indicates the direction of projectile motion.

rubber sheet are compressed vertically when the yoke is secured. The rubber then forms a seal to prevent gas from getting under the plug in the area of the rubber segments. The gas can then only exert vertical force on the plug over the area of the 40mm by 120mm groove and a narrow annular strip inside the O-ring in the plug.

Figure 5 shows the loader installed in the gas gun. The plug has been removed and inverted to show the cylindrical groove and O-ring seal. A projectile is shown in the groove of the loader body. The barrel, its attachment clamp, and the securing studs are shown to the right of the loader. The circular plate and large steel yoke are seen to the left; one can also see the firing solenoid valve and the front end of the breech chamber. In the foreground, one can see one of the large bolts for securing the yoke. The rubber sheet segments are not shown. An inch scale shows the relative size of the parts.

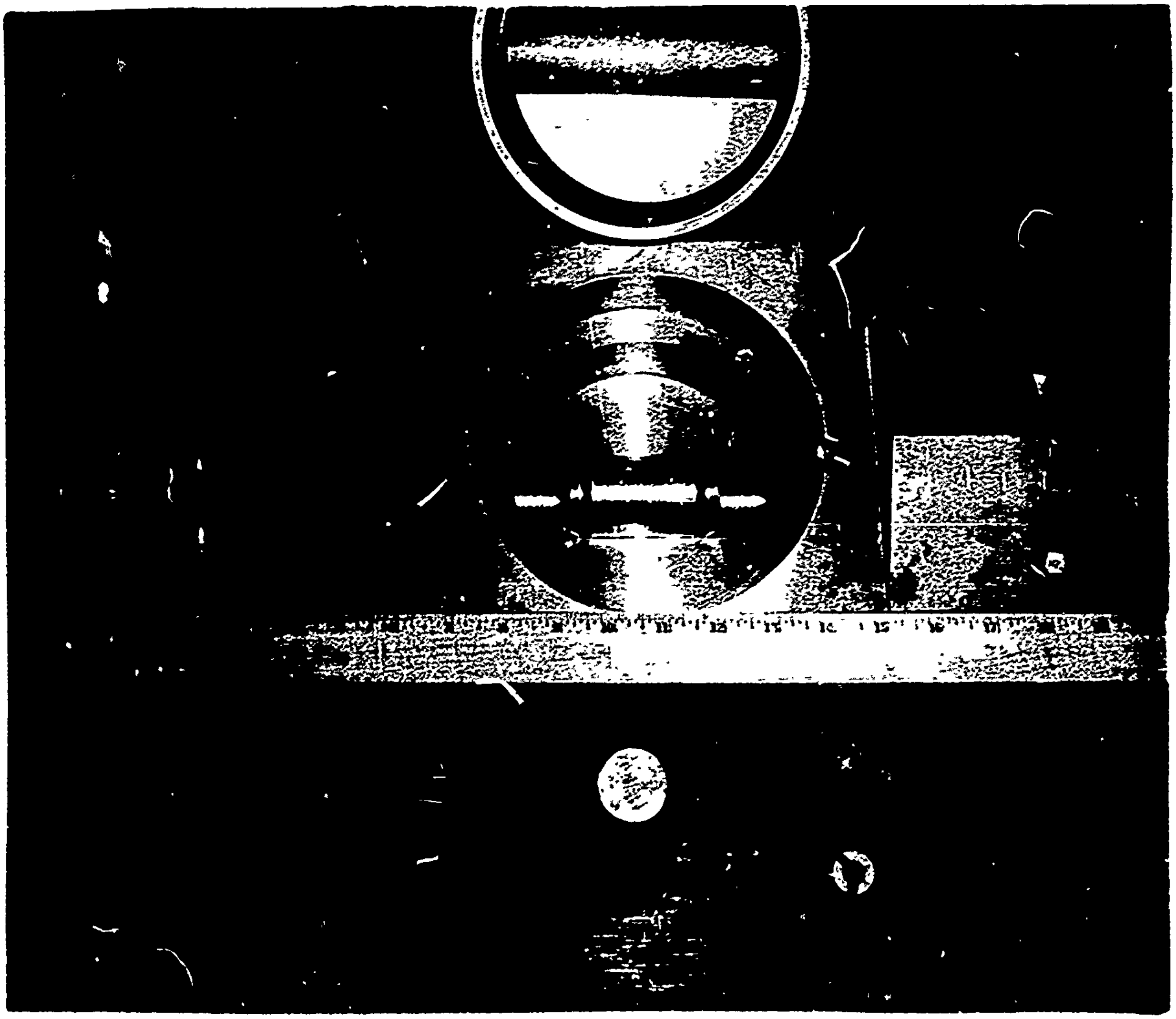

FIGURE 5

Photograph of Projectile Loader

IV. PERFORMANCE AND DISCUSSION

The new loader has performed satisfactorily. Two types of rubber sheet were tried; first, a soft silicone rubber, and then a much harder Viton rubber. After several test shots at breech pressures below 250 psi, one of the silicone segments was blown loose and followed the projectile down the barrel. After changing to the Viton we have had no further problems. Even after a dozen shots at pressures up to 1800 psi, no movement of the segments could be detected. It appears that the softer rubber was extruded from its normal position, into the gas flow area, by the vertical compressive force of the plug and yoke. Although we are currently limited to the use of gases from commercial cylinders (pressures to 1800 psi), we do not anticipate any problems at higher pressures to be used in the future.

One requirement for the new loader was that it be relatively simple to fabricate so as to minimize costs. The machining operations required to produce the loader were considered and were important to the design. The loader body was machined on a lathe and milling machine from a solid block of steel. The plug was machined from a separate solid piece. The design is such that only manual-control operations are required. The width of the loader could have been minimized by using a rectangular slot and rectangular plug; however, the easily machined circular hole and the plug replace a more complicated rectangular slot machining operation. The difficulties of machining a suitable rectangular O-ring groove are also avoided. (O-rings are generally preferred for demountable high-vacuum seals, over other types of gaskets.)

V. SUMMARY

Two existing designs for gas gun loading mechanisms have been discussed, and the merits of each reviewed. A new loader design has been described in detail. The reasons for considering this new design have been outlined along with its advantages. A projectile loader based on the new design has been incorporated in a 40mm bore gas gun, and performs satisfactorily.

REFERENCES

1. S. Thunborg, Jr., G. E. Ingram, and R. A Graham, *Rev. Sci. Instr.* **35**, 11 (1964).

2. R. A. Graham, private communication.

3. G. R. Fowles, G. E. Duvall, J. Asay, P. Bellamy, F. Feistmann, D. Grady, T. Michaels, and R. Mitchell, *Rev. Sci. Instr.* **41**, 984 (1970).